Erratum: Robust Limits on Lorentz Violation from Gamma-Ray Bursts

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Abstract

We correct the fitting formula used in refs. [1,2] to obtain a robust limit on a violation of Lorentz invariance that depends linearly on the photon energy. The correction leads to a slight increase of the limit on the scale of the violation, to $M > 1.4 \times 10^{16}$ GeV.

It has been resently pointed out in [3] that, due to the fact that the comoving distance that light travels while coming from an object at redshift z in the expanding Universe is bigger by a factor $(1 + z)$ than the proper distance [4], formula (1) in [1] (see also formula (13) in [2]) for the difference in the arrival times of two photons with energies differing by ΔE in the case of a linear violation of Lorentz invariance should be corrected to read:

$$\Delta t_{\mathrm{LV}} = H_0^{-1} \frac{\Delta E}{M} \int_0^z \frac{(1 + z)dz}{h(z)}, \tag{1}$$

where H_0 is the Hubble expansion rate,

$$h(z) = \sqrt{\Omega_\Lambda + \Omega_M (1 + z)^3}, \tag{2}$$

and we assume a spatially-flat Universe: $\Omega_{\mathrm{total}} = \Omega_\Lambda + \Omega_M = 1$ with cosmological constant $\Omega_\Lambda \simeq 0.7$.

As a result of this correction, the arrival time delays calculated in [1] should be fitted by a linear function, as in equation (4) of [1] but in terms of the variable:

$$K \equiv \frac{1}{1 + z} \int_0^z \frac{(1 + z)dz}{h(z)}. \tag{3}$$

The fit replacing the left panel of Fig. 2 in [1] is presented in Fig. 1. The linear fit corresponds to

$$\frac{\Delta t_{\mathrm{obs}}^{\mathrm{dw}}}{1 + z} = (0.0068 \pm 0.0067)\, K \; - \; (0.0065 \pm 0.0046), \tag{4}$$

and the likelihood function for the slope parameter analyzed in equation (14) of [1] is presented in Fig. 2 and, in fact, reflects better the sensitivity of the fit and in this sense replaces Fig. 4 of [1].

The 95% confidence-level lower limit obtained by solving equation (14) of [1] is

$$M \geq 1.4 \times 10^{16} \text{ GeV}, \tag{5}$$

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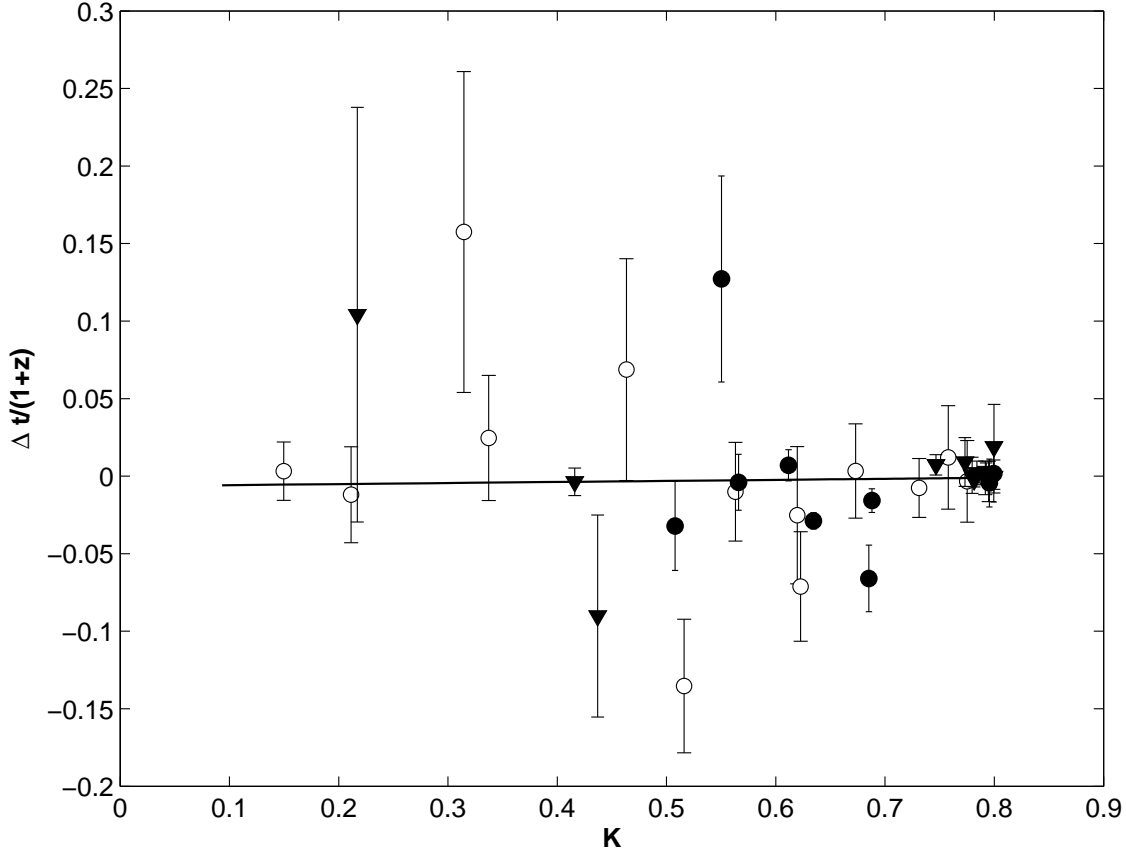(E.K.G. Sarkisyan).

Fig. 1. *The rescaled spectral time-lags between the arrival times of pairs of genuine high-intensity sharp features detected in the light curves of the full set of 35 GRBs with measured redshifts observed by BATSE (closed circles), HETE (open circles) and SWIFT (triangles).*

compared with our previous limit $M \geq 0.9 \times 10^{16}$ GeV.

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References

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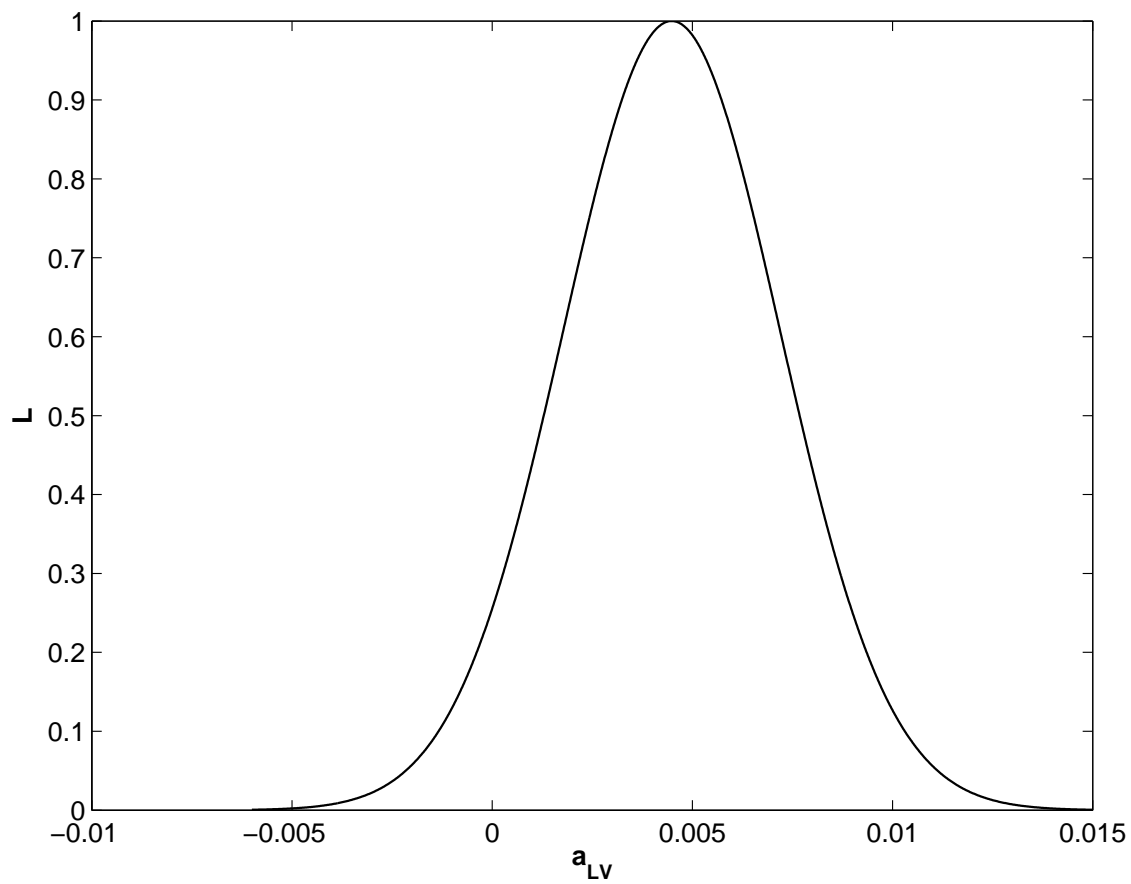[4] M. Rodriguez Martinez and T. Piran, JCAP **0604** (2006) 006 [arXiv:astro-ph/0601219].

Fig. 2. *The likelihood function for the slope parameter.*